us but little, although even here the links which unite *S. hirundinacea* of South America with *S. antarctica* of New Zealand, by way of the Southern Ocean, are very interesting. The distribution of the Skuas or Parasitic Gulls seems also clearly to connect the northern and southern hemispheres by way of the Pacific. It is, in fact, easier to specify the isolated groups which have *no* apparent connexion with the Pacific, foremost amongst which is that comprising the New-Zealand *L. bulleri* and *L. scopulinus*, the Australian *L. novæ-hollandiæ*, and the South-African *L. hartlaubi*. In the Arctic region there are the two isolated and specialized genera of Gulls, *Pagophila* and *Rhodostethia*, which are not known on the Pacific side; whilst amongst the Terns the intertropical genera *Nœnia*, *Anous*, and *Gygis*, although somewhat related *inter se*, offer no particular points of union with the typical *Sterninæ*. It is admitted that the present record is necessarily very imperfect, but it seems to me that the bulk of the evidence indicates the North Pacific as the centre of dispersal; and whether this view be accepted or not, I trust that the points to which I have drawn attention may at least show that Mr. A. R. Wallace's statement that the *Laridæ* are of little use in the study of geographical distribution is capable of a slight modification.

On the Action of Limpets (*Patella*) in sinking Pits in and Abrading the Surface of the Chalk at Dover.

By J. Clarke Hawkshaw, M.A., F.G.S. (Communicated by Dr. J. Murie, F.L.S.)

[Read April 18, 1878.]

(Abstract.)

The surface of the chalk which is exposed between high- and low-water mark on the foreshore to the east of Dover is covered by a series of small and finely grooved hollows made in the substance of the chalk. These abrasions of the surface are made by the limpets when feeding on the coating of delicate seaweed which covers the surface of the chalk.

When the rock has a good coating of this seaweed, the proceedings of any single limpet may be well seen. The lingual teeth make a small scoop or groove in the chalk; and as the animal makes a number of grooves one beside the other, a line is produced. After the limpet has completed a line, which is curved

with the concave side towards the animal, it reverses its action and makes another curved line, in which each new groove is made to the left of the last one. The first and second lines meet at a more or less acute angle; so the limpet moves over the ground making curved lines in alternate directions, which form a zigzag. Sometimes the angle which the curved lines make with one another is so small, and the lines are consequently so close together, that all, or nearly all, the surface of the chalk is subjected to the grooving. In such cases patches of freshly abraded chalk more than an inch square in area represent the work of a limpet probably in one tide. In other cases, when the animal had moved more rapidly over the ground, the result of such an excursion appeared in an open zigzag line. In these cases the length of the path of the animal was sometimes more than 12 inches—the length of the curved lines forming the zigzag being $\frac{3}{4}$ of an inch, and the width $\frac{1}{16}$ of an inch, but varying from that downwards, according to the size of the animal by which they were made.

On the part of the chalk foreshore immediately to the east of Dover, which is generally free from great inequalities or débris, limpets are very abundant, almost to the exclusion of other shellfish; and down to near low-water mark there is little or no seaweed, excepting the young growth, which appears to be removed with part of the surface on which it grows soon after it appears. The number of limpets to a square foot varied, in the few cases in which I had time to count them, from 5 to 9, omitting small ones less than about half an inch. Further to the east along the shore, where there has recently been a fall of the cliff, the shore is encumbered with blocks of chalk. Many of these blocks were covered with a matted coating of fine, semitransparent, ribbon-like seaweed. The limpets had not yet obtained a footing here; but I found one or two, conspicuous by the little clearing they had made in the midst of the seaweed. It was here possible to ascertain the area of surface which one limpet could abrade and keep clear of any but the youngest growth of seaweed. I measured some of these bare patches, and found them to vary from 8 to 14 square inches in area. The whole surface of these patches was closely grooved, the less recent work being covered with an incipient growth of seaweed. If one limpet could keep clear 14 square inches, it would require ten to keep clear a square foot, which agrees with my former estimate (small ones being omitted) of nine to a square foot where the rock was grooved all over.

It is not easy to estimate the amount of chalk removed by

limpets in the course of a year; but they must repeat the abrading process many times if they can, as some do, confine their operations to a few square inches of surface. Some of the best-defined grooves which I measured were $\frac{1}{50}$ of an inch in depth; but I think that the limpets in grazing over a surface which has been previously grooved have a tendency to deepen the first-made grooves in the centre; and if so, the above depth might be the result of several operations. As nearly as I can estimate it, the depth of chalk removed on a fresh surface is about ·006 of an inch; so that if we suppose the limpets to feed over the same area of surface ten times in a year, the total depth of chalk removed will be ·06, or about $\frac{1}{17}$ of an inch. In any case they do more to destroy the rock-surface than the sea ordinarily does. If this were not the case, the action of the sea would obliterate the marks made by the limpets, which it does not; for the surface of the chalk is free from the marks or grooves only along the base of the cliffs where the shingle is washed about by the waves, and in a few holes and gullies where loose pebbles are rolled to and fro.

The limpets do a great deal of apparently unnecessary work in rasping away so much chalk; but it may be beneficial to them in preventing the settlement of sedentary rivals, such as *Balani* or the larger seaweeds, and so enabling them to keep a large surface of pasture-ground to themselves. The rasped surface seems to be soon covered again by the fine green coating on which, I presume, they feed. They rasp close round any hard object, such as a piece of shell or flint imbedded in the chalk; so that any *Balanus* or other sedentary growth would be left on an exposed pedestal of chalk, and, as the chalk is soft on the surface, would be liable to be washed off by the waves. On a large block of chalk which was tenanted by a quantity of limpets, so that every part of the surface was rasped over by them, I noticed one or two solitary *Balani*. The raspings extended close round the base of the shells of the *Balani*, and must have tended to weaken their hold on the rock. Yet a large proportion of the shells of the limpets had five or six large *Balani* on them. It would appear probable from this that there was something which made the chalk an unsuitable resting-place for *Balani*; and the action of the limpets may not unlikely be the cause. The limpets certainly had the foreshore almost entirely to themselves down to low-water mark. These comparatively large areas of rock-surface covered only by a short vegetable growth, and browsed over by

limpets, remind one, in a small way, of the llanos or pampas on the land, where arboreal vegetation is kept down by herbivorous animals. Yet the limpets appear to do their work more effectually, as they uproot all alien growths.

The holes in the chalk, in which the limpets are often to be found, are, I believe, excavated in a great measure by rasping with the lingual teeth, though I doubt whether the object is to form a cavity to shelter in, though the cavities, when formed, may be of use for that purpose. It must be of the greatest importance to a limpet that, in order that it may ensure a firm adherence to the rock, its shell should fit the rock accurately; when the shell does fit the rock accurately, a small amount of muscular contraction of the animal would cause the shell to adhere so firmly to a smooth surface as to be practically immovable without fracture. As the shells cannot be adapted daily to different forms of surface, the limpets generally return to the same places of attachment. I am sure this is the case with many; for I found shells perfectly adjusted to the uneven surfaces of flints, the growth of the shells being in some parts distorted and indented to suit inequalities in the surface of the flints. As the edges of the shells, especially those of the younger animals, are very sharp, the effect of pressure brought to bear on the edge, either by the contraction of the animal or by the shock of the waves, would, if there is the least sideway movement, be to cut into the chalk round the edge of the shell. The muscles of the animal are generally relaxed when reposing; for if the point of a knife be quickly inserted beneath the edge of the shell, it may be detached from the rock without difficulty; but if the least warning by a touch be given to the animal, its muscles contract, and it adheres so firmly that it is impossible to detach it without breaking the edge of the shell*. These alternate relaxations and contractions on sudden alarms would tend to increase the effect of the cutting action of the edge of the shell. I saw the fine indentations round the edge of some of the shells exactly reproduced upon the surface of the chalk; and this could only result from pressure on the shell forcing its sharp edge into the chalk. A very little pressure, as may be found by trial, will suffice to force the edge of the shell into the chalk. The effect of the formation of a groove in the chalk corresponding with the edge of the shell

* Reaumur found that a limpet could sustain a weight of from 28 to 30 pounds for some seconds (Jeffreys, 'Brit. Conch.' vol. iii. p. 232).

would be to diminish the internal capacity of the shell, and possibly to cause discomfort to the animal, or prevent its obtaining a firm hold on the rock. As all the surface of the chalk outside the shell becomes covered with the fine growth of seaweed, the outer side of the groove round the edge of the shell, which forms the side of the pit, becomes in like manner covered with seaweed, and is pared away to a slope. This assists the cutting effect of the edge of the shell, as it is more effective against the foot of a slope than it would be if the face of the pit were perpendicular. I noticed one case in which a limpet appeared to have pared away one side of the pit, that opposite the head of the animal, as fast as the pit had been sunk. The animal had begun to browse from the edge of the shell outwards.

The above appears to me to be an explanation of the manner in which the habit of sinking pits may have been acquired by limpets. But in many cases they now appear to excavate deeper pits than would be required for the removal of the protuberance, extending the excavation below the plane of the rim of the shell. For what purpose this is done I do not know, unless it be to get a clean surface of chalk to adhere to, as their slimy bodies would detach pieces of chalk in time, and possibly render their hold less secure. Small pieces of chalk do adhere to the animals when you remove them from the rock. These hollows which they excavate below the plane of the rim of the shell are, when completed, basin-shaped, sloping away from the edge of the shell. At first they are begun beneath the head of the animal, and a considerable hollow is often made there before the excavation is extended round the sides backwards. During the process of excavation a lump is left in one stage in the centre.

When a limpet has sunk some distance into the chalk by the above processes combined, the pits are further enlarged by smaller limpets sinking secondary ones and browsing on the seaweed which grows on the sides of the pits.

I noticed signs that limpets prefer a hard smooth surface to a pit in the chalk. On one face of a large block, over all sides of which limpets were regularly and plentifully distributed, there were two flat fragments of a fossil shell about 3 inches by 4 inches, each imbedded in the chalk. The chalk all round these fragments was free from limpets; but on the smooth surface of the pieces of shell they were packed as closely as they could be. I noticed another case which almost amounts, to my mind, to a proof that they prefer a smooth surface to a hole. A limpet had

formed a clearing on one of the seaweed-covered blocks before referred to. In the midst of this clearing was a pedestal of flint rather more than 1 inch in diameter, standing up above the surface of the chalk: it projected so much that a tap from my hammer broke it off. On the top of the smooth fractured surface of this flint the occupant of the clearing had taken up its abode. The shell was closely adapted to the uneven surface, which it would only fit in one position. The cleared surface was in a hollow with several small natural cavities, where the limpet could have found a pit ready made to shelter in; yet it preferred, after each excursion, to climb up on to the top of the flint, the most exposed point in all its domain.

In South America our limpets have, I believe, representatives with shells a foot in diameter. If the proceedings of these South-American giants are at all the same as those of the limpets of our own shores and are in proportion to their size, they must materially aid in the encroachment of the sea on the land when the rock happens to be soft *.

Notes on the Presence of *Tachyglossus* and *Ornithorhynchus* in Northern and North-eastern Queensland. By Capt. William E. Armit, F.L.S.

[Read June 20, 1878.]

Some doubt having been evinced of the existence of *Tachyglossus* and *Ornithorhynchus* in Northern Queensland, I am desirous of laying a few facts before the Society, which will establish the extreme northern limit of the species as far as yet known.

Tachyglossus occurs at Bellenden Plains, situated some thirty miles north-east of Cardwell, in about 18° S. latitude. It frequents the scrubs on the mountains and river-banks, and on one occasion, in 1873, I found the hind legs of one in a black fellow's "dilly-bag." At Georgetown, distant some 200 miles west of Cardwell, this animal is pretty common; and last year I succeeded in capturing three males. One adult female I secured in 1876, having a fine young one in the pouch. All the above speci-

* Subsequent to the reading of the foregoing, my attention was called to a paper by Fred. C. Lukis ('Mag. of Nat. Hist.' 1831, vol. iv. p. 346), wherein figures of limpet-tracks are given. Although I find that, independently, I corroborate his observations, nevertheless, so far as I can learn, the bulk of my facts and suggestions have not hitherto been dwelt on by previous writers.